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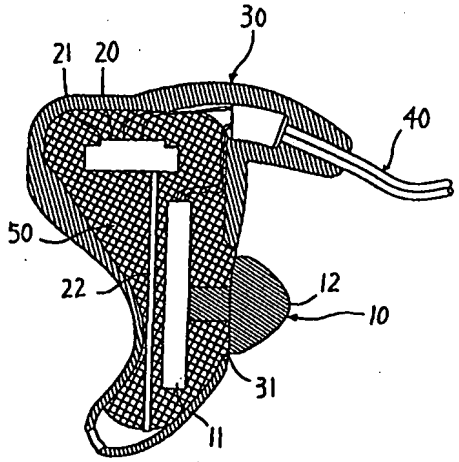
(54) Title: EAR-INTEGRATED TELEPHONE TRANSMITTER AND RECEIVER WITH HIGH SUPPRESSED FEEDBACK

(54) 发明名称: 高抑制反馈的耳道式一体化送、受话器




(57) Abstract: An integrated car-mounted transmitter and receiver which is used in a communication and having high suppressed feedback, comprises: transmitter unit (10) which is composed of transducer (11), protrusion-like pickup piece (12) and sound processing circuit (13); receiver unit (20) which is composed of speaker (21) and sound-transfer tube (22) connected with it; housing (30) accommodated to ear duct-type and wire (40) connected with transmitter unit and receiver unit, characterized in that transmitter unit (10) and receiver (20) are isolated by high damping material, and at least transmitter and housing are isolated by high damping material; a part of protrusion-like pickup piece protrudes from hole (31) of housing (30), and protrusion-like pickup piece is isolated with hole wall. Present invention reduces the vibration signal from receiver unit since vibration damping capability of high damping material, and reduces effectively feedback of duplexing work, so it can preferably eliminate howling and echo, reduce noise signal, improve sound quality and carry comfortably.

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(57) 摘要

一种通讯用的高抑制反馈的耳道式一体化送、受话器，它包括由传感器 11、凸状拾振块 12 及声音处理电路 13 构成的送话器组件 10、由扬声器 21 及与之相连的导声器 22 构成的受话器组件 20、与耳道形状相适应的外壳 30 及与送话器组件和受话器组件相连的导线 40，其特征在于，送话器组件 10 与受话器组件 20 由高阻尼材料 50 隔开，且至少将送话器与外壳也用该高阻尼材料 50 隔开；所述凸状拾振块 12 的一部分从外壳 30 上的孔 31 处伸出，且拾振块与孔壁之间保持隔离状态。本发明通过高阻尼材料具有的减振性能将受话器组件传出的振动信号尽量减弱，有效降低双工工作时的反馈，因而可较好地消除啸叫和回声，并可尽量减少干扰信号的传入，从而提高声音器质，且佩戴更加舒适。

# 高抑制反馈的耳道式一体化送、受话器

## 技术领域

本发明涉及通讯用的送、受话器，特别是涉及一种用于双工通讯的高抑制反馈的耳道式一体化送、受话器。

## 背景技术

随着便携式电脑和通讯终端的越来越广泛地使用，与之相关的具有高抗噪音性能且体积小的拾振式麦克风也将会得到更广泛的应用。拾振式麦克风也称骨导式麦克风，其工作原理是：当人说话时，在声带振动发出声波的同时，也会引起人体组织的振动，振动拾取传感器拾取这些振动作为声间信号源。由于振动拾取传感器对周围空气介质中的声波不敏感，而对与其接触的人体组织的振动则更为敏感，因此，振动拾取式麦克风就具有更优良的抗环境噪声能力。根据振动拾取的人体部位的区别，拾振式麦克风又分为头顶式、喉结式、耳道式等。头顶式和喉结式常用于军队和警察等专业部门，它们的主要缺点是佩带既不美观，也不方便，其中，喉结式麦克风由于是压在人的颈部，因而长时间佩戴会引起使用者的不适，而头顶式麦克风则因为必须要佩戴头盔而不常使用。

为了克服上述拾振式麦克风的不足，人们研究出了耳道式麦克风，较好地解决了上述问题。耳道式麦克风的振动拾取点是在人的耳道部位，并由此可以把送话器与受话器合为一体，放入耳道中，因而同时具有听和说两种功能。本申请人在中国发明专利 98106573 中公开了一种上述的耳道式送、受话器，其发明主题为“带有振动拾音器的一体化耳道式送、受话器”，它包括一个与耳道形状相适应的软体材料制成的外壳及与导线相连的振动式送话器及受话器。其中，振动式送话器采用压电陶瓷作为传感器，在传感器的后端采用悬臂梁结构固定于固定端上，在传感器的前端设有质量块(配重)以放大信号，传感器将振动信号转变成电信号，并经阻抗匹配电路处理后输出。传感器的外部是壳体，并且在壳体上设有一个用于拾取振动

信号的凸状拾振块。传感器、固定端、配重、阻抗匹配电路、壳体、凸状拾振块共同组成了送话器组件。

上述送、受话器的最大特点是：对信号采用了机械方法处理，使声音音质有了很大改进。由于人们在讲话时，声带振动引起的人体组织振动会沿各个方向传播，从而到达耳道的不同方向的各个部分，而且振动相位也是不同的，如果全部接收，就会产生混音，使得到的声音的音质和识别性不好。所述凸状拾振块采用硬质材料制成，使耳道内振动拾取部位的振动信号能尽量传导进来，而外壳采用软体材料制成，由于软体材料具有减弱振动的作用，因而能使其它部位传入的信号尽量减弱，从而使声音的音质还原度高，失真小。同时，由于把振动式拾音器及受话器放在一起，在同时进行说和听的双工状态下，受话器发声时传出的振动会被振动式拾音器拾取，从而产生反馈，导致通话时有回声甚至啸叫出现，软体材料制成的外壳的减弱振动的能力还可以起到抑制反馈的作用。另外，软体材料制成的外壳对人们的不同大小的耳道有较好的适应性，还可以使佩戴舒适。

然而，在实践中发现，该耳道式送/受话器如要得到硬广泛的应用，则仍有一些问题需要解决，具体表现为：

1、用作外壳的软体材料的减振能力有限，使得外壳抑制反馈的能力亦非常有限，在双工状态下，还是常常会导致回声出现；

2、同样原因，在振动式拾音器工作时，虽然能使其它部位的信号尽量减弱，但仍会有干扰信号传入，从而降低声音品质；

3. 软体材料制成的外壳的弹性有限，当使用者的耳道较小时，它还是不能完全适应，并使使用者产生不适应。

上述问题的产生表明，现有软体材料的减弱振动的能力有限的，而且仅外壳采用软体材料也无法解决上述问题。

## 发明内容

本发明就是为解决现有耳道式送、受话器所存在的诸多问题，而提供一种具有高抑制反馈能力的耳道式一体化送、受话器。

本发明的高抑制反馈的耳道式一体化送、受话器包括由传感器、凸状拾振块及声音处理电路构成的送话器组件、由扬声器及与之相连的导声管构成的受话器组件、与耳道形状相适应的外壳、及与送话器组件和受话器组件相连的导线，其特征在于，送话器组件与受话器组件由高阻尼材料隔开，且至少将送话器与外壳也用该高阻尼材料隔开；所述凸状拾振块的一部分从外壳上的孔处伸出，且拾振块与孔壁之间保持隔离状态。

所述高阻尼材料采用泡沫塑料或泡沫橡胶

所述外壳是由硅基高分子材料制成的薄壳。

本发明的贡献在于，由于采用高阻尼材料作为填充材料，不仅起到固定送、受话器各元器件的作用，而且更重要的是通过高阻尼材料将各元器件相互隔离，通过其良好的减振性能将受话器和声导管传出的振动信号尽量减弱，有效地抑制双工工作时的反馈，因而可较好地消除啸叫和回声。由于用高阻尼材料将送话器与外壳隔离，因而可以尽量减少干扰信号的传入，从而提高声音品质。还由于所采用的高阻尼材料具有良好的形变能力，因而可根据耳道形状自适应地调节凸状拾振块的凸出高度，使佩戴更加舒适。此外，由于外壳采用硅胶及类似的材料制成，形状确定，外壳表面光滑，与人体组织的亲和性好，因而佩戴舒适。

## 附图说明

图 1 是本发明的外形示意图。

图 2 是本发明的结构剖视图。

图 3 是本发明的送话器组件结构示意图。

图 4 是本发明的受话器组件结构示意图。

图 5 是本发明的结构透视图。

## 具体实施方式

下面结合附图及优选实施例对本发明作进一步说明。

参阅图 2~图 5，本发明的高抑制反馈的耳道式一体化送、受话器包括

送话器组件 10、受话器组件 20、外壳 30 及导线 40，其中送话器组件 10 由传感器 11、凸状拾振块 12 及声音处理电路 13 构成，传感器采用压电陶瓷传感器，它纵向设置于外壳内，其一端固定，经过声音处理电路 13 后与导线 40 连接，另一端为自由端，形成悬臂梁结构，在悬臂端可设置一质量块（配重）14，使振幅增大以便放大信号。所述凸状拾振块 12 的前端从外壳 30 上的孔 31 处伸出，直接与耳道接触拾取振动信号。该拾振块由硬质材料制成，以有效地传递振动。所述声音处理电路 13 为阻抗匹配电路，其一端与传感器固定端连接，另一端则通过导线 40 与外部设备连接，该电路用于对经凸状拾振块 12 输入的声音信号进行阻抗变换后经导线 40 输出。所述受话器组件由场声器 21 及与之相连的导声管 22 构成，扬声器 21 是一微型扬声器，它横向设置于外壳内靠顶端处，并通过导线 40 与外部设备相连接。为将扬声器的声音导出，在扬声器上连接有一导声管 22，它延伸至送、受话器前端出口处，可将扬声器收到的来自外部设备的话音导出到使用者耳道中。所述外壳 30 是由硅基高分子材料，如硅胶等制成的薄壳，其形状与人体耳道形状相适应，这类材料制成的外壳具有表面光滑，与人体组织的亲和性好、无毒、材质较结实等特点。在外壳的端部开有供导线穿过的孔，另一端也开有孔，用于将由导声管送来的声音传出，外壳的侧中部开有供凸状拾振块 12 伸出的孔 31。导线 40 的一端与送话器组件及受话器组件相连，另一端则与外部设备相连，用于传输信号。

上述结构与现有技术基本相同，本发明的要点在于，为克服在同时进行说和听的双工状态下，受话器发声时传出的振动会被振动式拾音器拾取，从而产生反馈，导致通话时有回声甚至啸叫出现的问题，本发明将送话器组件 10 与受话器组件 20 由高阻尼材料 50 隔开，同时为尽量减少外界干扰信号的传入，提高声音器质，还必须至少将送话器与外壳也用该高阻尼材料 50 完全隔开。受话器组件可用高阻尼材料与外壳隔开，也可不隔开。该高阻尼材料是解决问题的关键，它应具备良的减振性能和形变能力，最好还应具有慢回弹特性，以适应不同的耳道及延长其使用寿命。这种高阻尼材料可选用泡沫塑料，如聚氯乙烯泡沫塑料、聚苯乙烯泡沫塑料、脲醛泡

沫塑料和聚氨酯泡沫塑料等，本例中优选聚氨酯泡沫塑料。也可选用泡沫橡胶，即海绵状多孔结构的硫化橡胶。可根据需要选择合适的市售产品。实施时，可将上述高阻尼材料填充于送话器组件与受话器组件之间以及送、受话器组件与外壳之间，以起到减振和固定元器件的作用。本发明的另一要点是，所述凸状拾振块凸出部分从外壳 30 上的孔 31 处伸出，为防止拾振块的外边缘与孔壁接触而产生杂音，庆使得拾振块与孔壁之间保持隔离状态，其措施是使外壳 30 上的孔 31 的直径大于凸状拾振块的外部尺寸，并将孔 31 的边缘与凸状拾振块之间也由高阻尼材料隔开。

本发明的耳道式送、受话器的音质更好，佩戴更方便舒适，最重要的是基本无回声，可以满足民用双工通讯的要求。

# 权 利 要 求 书

1. 一种通讯用的高抑制反馈的耳道式一体化送、受话器，包括由传感器（11）、凸状拾振块（12）及声音处理电路（13）构成的送话器组件（10）、由扬声器（21）及与之相连的导声管（22）构成的受话器组件（20）、与耳道形状相适应的外壳（30）及与送话器组件和受话器组件相连的导线（40），其特征在于，送话器组件（10）与受话器组件（20）由高阻尼材料（50）隔开，且至少将送话器与外壳也用该高阻尼材料（50）隔开；所述凸状拾振块（12）的一部分从外壳（30）上的孔（31）处伸出，且拾振块与孔壁之间保持隔离状态。

2. 根据权利要求 1 所述的高抗噪耳道式送、受话器，其特征在于，所述高阻尼材料（50）采用泡沫塑料或泡沫橡胶。

3. 根据权利要求 1 所述的高抗噪耳道式送、受话器，其特征在于，所述外壳（30）是由硅基高分子材料制成的薄壳。

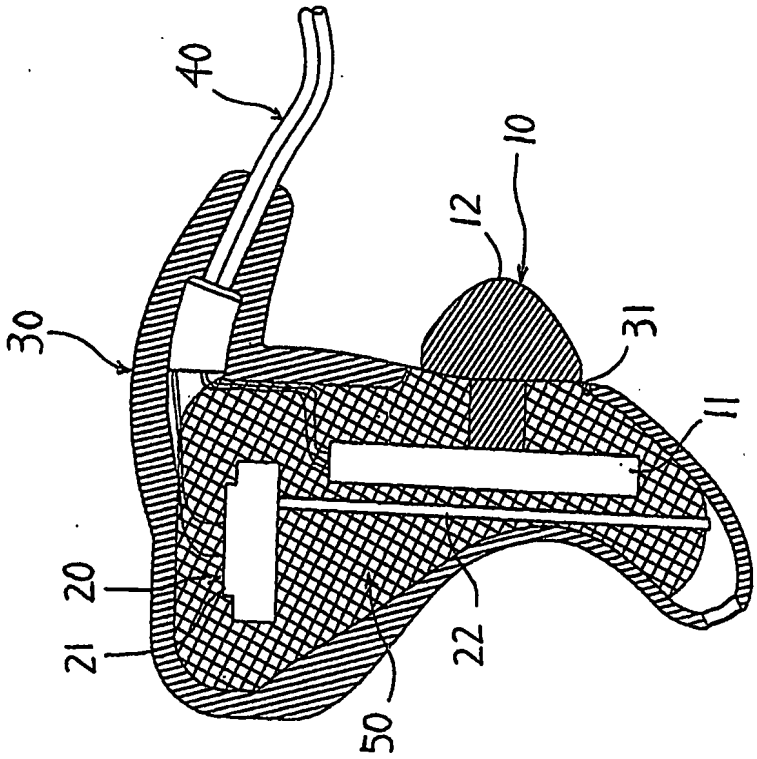


FIG. 2

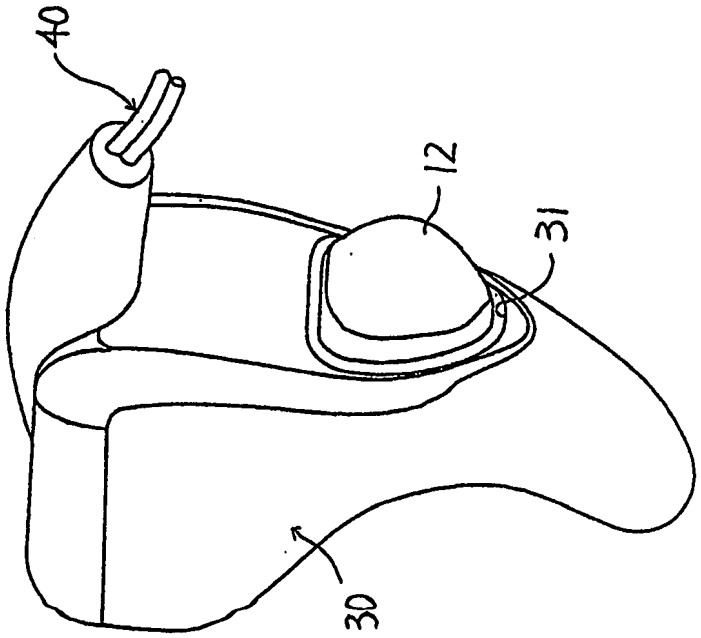


FIG. 1

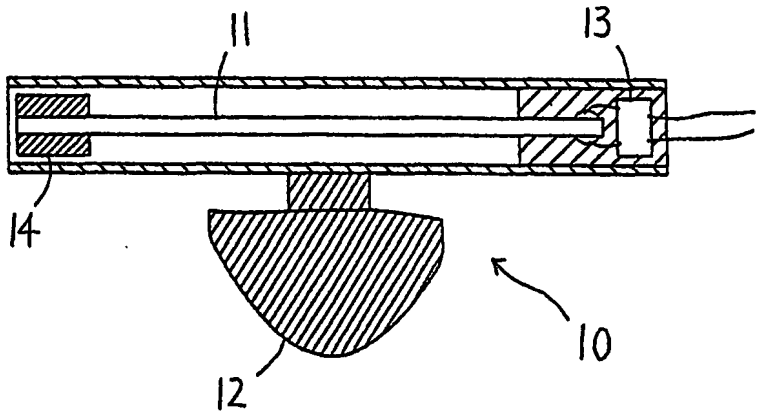


FIG. 3

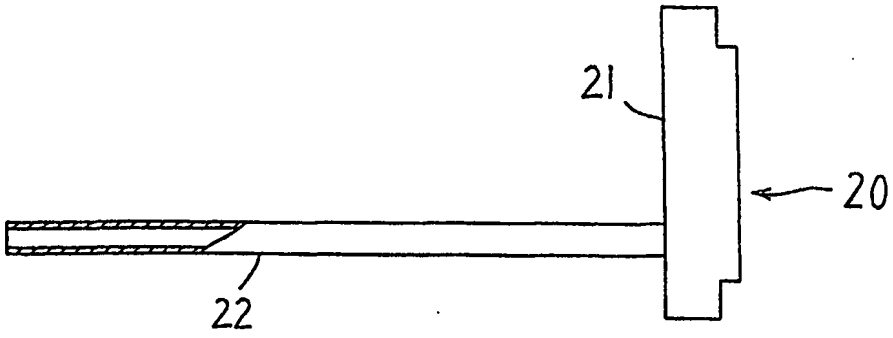


FIG. 4

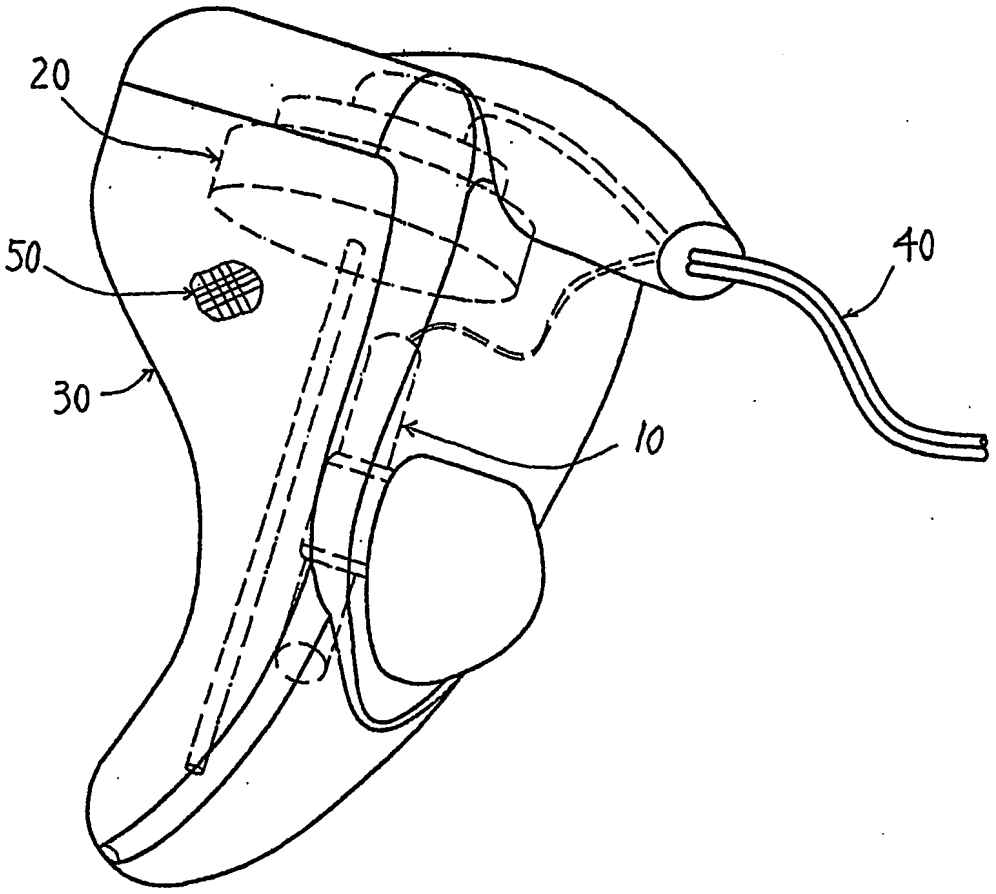


FIG. 5

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN02/00556

A. CLASSIFICATION OF SUBJECT MATTER

IPC[7]: H04R 1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC[7]: H04R 1/00 H04R 1/02 H04R 1/08 H04R 1/10 H04R 1/16

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT WPI EPODOC PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | CN1193236 A(Chenhao et al.)<br>16 September 1998<br>see figures 1 - 6<br>see page. 3, line 26 - page.4, line 24 | 1, 3 |
| A | JP9331591 A (MITSUBISHI ELECTRIC CORP)<br>22 December 1997<br>see whole document | 1, 2 |
| A | JP4172794 A (ONO HIROSHI)<br>19 June 1992<br>see whole document | 1 |

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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| CN1193236 A | 1998-09-16 | WO9946955 A | 1999-09-16 |
| | | AU2710399 A | 1999-09-27 |
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# 国际检索报告

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A. 主题的分类

IPC[7]: H04R 1/00

按照国际专利分类表(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类体系和分类号)

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包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称和，如果实际可行的，使用的检索词)

CNPAT WPI EPODOC PAJ

C. 相关文件

| 类 型* | 引用文件，必要时，指明相关段落 | 相关的权利要求编号 |
|---|---|---|
| A | CN1193236 A (陈皓 等) 1998年9月16日（16.09.98），第3页第26行—第4页第24行，图1—6 | 1、3 |
| A | JP9331591 A (MITSUBISHI ELECTRIC公司) 1997年12月22日(22.12.97)，全文 | 1、2 |
| A | JP4172794 A (ONO HIROSHI) 1992年6月19日（19.06.92），全文 | 1 |

☐ 其余文件在C栏的续页中列出。 ☒ 见同族专利附件。

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(54) Title: RECREATIONAL BONE CONDUCTION AUDIO DEVICE, SYSTEM


(57) Abstract: A waterproof recreational audio device and method that transmits sound via transcutaneous bone conduction provides high fidelity musical signals to a user. The device can be worn on the head of a user and integrated into various types of headgear. The device is tunable for sound quality and comfort by adjusting and moving the sound transmitting transducers around the head of the user. The present invention uses commercially available transducers to produce sounds in the low, mid and high frequency ranges. A sound source for the musical signal can also be provided as part of the waterproof recreational audio device. Controls enable the user to select volume levels for the high, mid and low frequency ranges, while a volume limiter restricts the mid range to a preset maximum volume level to allow external ambient sounds to be heard via the ear canal and protects the hearing of the user.

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# RECREATIONAL BONE CONDUCTION AUDIO DEVICE, SYSTEM

## DESCRIPTION

## BACKGROUND OF THE INVENTION

*Field of the Invention*

The present invention generally relates to waterproof recreational audio devices and, more particularly, to recreational audio devices that provide high quality musical sound to users through bone conduction sound transmission and the methods related thereto.

*Background Description*

Since the introduction of the Sony Walkman in July of 1979, over 100 million units have been sold. The Oxford English Dictionary certified 'walkman' as a noun in 1986 describing it as a personal audio device. The recreational audio device has established itself as a mainstay for personal music enjoyment. Advances in the personal audio device market have typically been focused in two areas: size of the unit and headphone improvements. Headphones for personal audio systems have historically been air conduction systems that rely on tympanic hearing for sound transmission.

In tympanic hearing, sound travels through the ear canal to the eardrum making it vibrate. These vibrations are passed to three small bones in the middle ear, the ossicles, by a process called air conduction. These in turn pass the vibrations to the cochlea and the fluid it contains. Movement in this fluid bends the tiny hair cells along the length of the

cochlea, generating signals in the auditory nerve. The nerve signals pass to the brain, which interprets them as sound. Bone conduction hearing is when sound vibrations are transmitted directly from the skull and jaw bones to the cochlea, missing the outer and middle ears. Air conduction sound systems provide stereo quality sound by taking advantage of the ability of the human brain to take in sound from the two ears and integrating the multiple sound sources into a single, richer sound. While bone conduction devices have traditionally been developed for the hearing impaired and as hearing aid devices until recently, these devices focused on transmitting sound in the speaking voice frequency range and have not been adapted for high fidelity musical signals. Additionally, the recreational audio systems for the underwater environment have traditionally relied on air conduction with ear plugs for the sound transmission.

While small, streamline systems exist for land based recreational audio, they are predominately of the air conduction type. Several of these systems have been waterproofed for use by swimmers. These systems rely on ear plugs that are placed in the ear such that an air bubble is formed in the ear canal. When this bubble is intact, the sound transmission is acceptable. However, the ear canal acoustic resonance is lost if it fills with water while the head is submerged. With bone conduction sound transmission, this disadvantage is overcome. Specifically, when the ear canal is filled with water, as when a swimmer is submerged, the mass of the water (4.5 times denser than air) acoustically loads the ear drum enhancing low frequency sound reception in the ear to bone conduction [Tonndorf, J. A New Concept of Bone Conduction, *Arch Otol* 87, 49 - 54 1968].

Common bone conduction type devices have been developed to transmit sound in the speech frequency range and have not been maximized to provide musical sound quality. In addition, bone conduction

devices have been either large units that were heavy, bulky and uncomfortable for the user or have been devices integrated into a bite plate for sound transmission via the jaw bone (May US Patent 5,579,284).Bit plate type of sound transmission actually requires the user to continually bite down on the device in order to hear the sound.

An audio systems using bone conduction is shown in U.S. Patent 4,791,673 to Schreiber. This invention is an audio listening system that includes both a bone conduction device and a sound source unit. The system has a transducer mounted in a c-shaped element that hooks around the ear of the user. A suction cup element is included as part of the transducer feature to ensure contact from the transducer to the mastoid region behind the ear of the user. This device is water resistant but not waterproof and has only one type of transducer to transmit sound to the user.

A further device is shown in U.S. Patent 5,323,468 to Bottesch that provides a means for the conduction of sound waves through the mastoid bones of the user and selectively amplifying predetermined frequency ranges that the invention claims do not conduct well through the bone so as to maximize the transmission of all signals in the sound source frequency range. The invention is a small, light weight head gear that puts one or several transducers in contact with the mastoid region of the skull. The headgear is designed to provide stereophonic music to the user by transmitting the stereo sound signals separately to transducers located behind the ear of the user. This device is not waterproof and only provides one type of transducer for transmitting across the multiple frequency ranges.

A third bone conduction device is shown in U.S. Patent 5,889,730 to May that provides an underwater audio communication system for transmitting voice through bone conduction at the mastoid region of the head. This device is designed to allow voice communication to and from

an underwater user. The device mounts one or more of the same type transducers onto the users scuba face mask. A transceiver and amplifier is located on the back of the users head to transmit and receive ultrasonic sound signals for communication with the user.

## SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a waterproof recreational audio device to allow a listener to hear high fidelity musical signals through transcutaneous bone conduction.

A further object of the invention is to provide high fidelity sound by maximizing the quality of the sound transmission across the three frequency ranges of musical sound.

Another object of the present invention is to provide an integrated recreational audio system that includes both the headphone unit and the signal source unit.

Additionally, an object of the present invention is to enable the user to position the device on the head for tuning of the sound for the user.

The waterproof recreational audio device of the present invention has an enhanced frequency range over that of previous devices so as to overcome the limited sound quality of existing bone conduction systems. In addition, the present invention is integrated into a light weight headgear that is more comfortable than previous hearing aid type units to enable the individual user to adjust the headgear for personal preferences. The waterproof recreational audio device is also constructed to enable high quality musical signals to be 'heard' while in an underwater environment. However, the intended environment should not be construed as limiting the device to this use. Athletic users may appreciate the light weight, waterproof and streamline configuration of the invention while engaging in other athletic activities such as running, biking, hiking, etc.

According to the present invention, the foregoing and other objects are achieved in part by having a transducer in contact with the skull of the user for transmitting musical signals via bone conduction. The musical signals differ from ordinary speech in that the average frequency range for normal speech is approximately 120 Hz to 8,000 Hz, while high fidelity musical signals can range from 20 Hz to over 20, 000 Hz. This range can be extended even further to meet the newer digital sampling technology with high frequencies of almost 40,000 Hz.

The present invention has at least one transducer that is able to transmit transcutaneous sound via bone conduction through the head of the user. The present invention is functional with at least one transducer, however, at least one transducer should also be understood to include a plurality of transducers. An amplifier can also be worn on the head of the user or can be part of a signal source unit to which the transducer or transducers are connected. The present invention is intended to be worn on the head of the user. The transducer may be fixed to a band that encircles the head of the user or other head gear such as hats, helmets, headbands, or eye wear such as goggles, face mask or sun glasses.

The musical frequency range is split into three distinct channels by the present invention. That is: low frequency from 0 Hz to 1000 Hz, mid frequency from 25 Hz to 6,000 Hz and high frequency from 5,000 to over 20,000 Hz. With new digital sampling device, the upper end frequency range can extend to as high about 40,000Hz. The present invention can use commercially available transducers coupled with the amplifier to produce sound in the mid frequency range. The low frequency response is achieved by applying very low frequencies to the head using a vibrotactile transducer. To provide the high frequency musical signal to the user, the present invention can also include an ultrasonic transducer. The ultrasonic transducer may be of a piezoelectric type or similar. Each channel requires special amplification provided by the invention. The low frequency has

low impendence whereas the high frequency device has about 10 times the impedance. Thus, the three channel amplifier is designed to three different impedances. In addition, each of these frequency channels can have their own volume adjustment. The upper end of the volume can be preset to reduce potential damage to the listener. The preset volume can also be limited specifically for the mid frequency range to allow the user to hear external environmental sound and to provide a volume limit such that others in close proximity to the user do not hear the sound signal from the present invention if the device is worn other than underwater.

Perceptually, bone conduction using the three channels of sound, results in a high fidelity sound quality for the purpose of music listening. The three channels, when listened to underwater, permit a flexible sound quality that allows changes in the sound envelope appropriate for musical articulation. The low frequency range channel proposed is conducive to low and high pitch sounds that enhance the appreciation of both human voice and instrumental applications for music. With air conduction minimized by water or earplug, the proposed device also offers unique clarity with minimal distortion. Further, the impediment of air conduction, through water or earplug, with this device also reduces noise that can hamper music appreciation. The sound quality from the three channel device with its three transducers is omnidirectional when heard underwater. With ear masking as described, it has a timbre that is comparable to high fidelity instrumentation with above-surface stereophonic attributes.

The waterproof recreational audio device can also enhance the music signal by enabling tuning of the device to the individual users preference through positioning of the transducers on the users head. The human skull is very asymmetrical with regard to its vibratory response. In addition, there are idiosyncratic vibratory differences due to individual specific skull geometries [Cai, Z., Richards, D. G., Lenhardt, M.L. and

Madsen, A.G., Response of the Human Skull to Bone Conducted Sound in the Audiometric to Ultrasonic Range., *International Tinnitus Journal*, 8, 1, 1 - 8, 2002]. The transducers of the device can be placed in a standard position (i.e., over the ear in the mastoid region and on the forehead in the frontal region, etc.). However, the sound quality may not be considered optimum for some users. To compensate for the acoustics in skull geometry, the transducers can be placed on the head band 180° apart, or at another desired orientation, allowing the user to rotate the band around the head to select the position of best music reception. This can be readjusted underwater due to the different acoustic properties of that medium and its interaction with the head. In a second embodiment, each transducer may be moveable about the head band independently, until the best sound reception is achieved. This allows custom tuning for each frequency band resulting in the greatest user satisfaction.

As a waterproof recreational audio device, the present invention has a further embodiment that integrates the sound source with the sound transmission. This sound source can be in the form of a disk player (e.g., CDs, DVDs, minidiscs, etc.), MP3 player, AM/FM radio, audio transceiver or other such devices known as personal audio devices. The sound source can communicate with the transducers by wireless or wired connection.

Finally, the objects are met by providing the functional elements and a method for positioning the transducers at various locations on the head of the user. The transducers may be fixed to the band or other head gear and the head gear would be rotated around the head. In addition, the transducers may be able to slide to different locations around the head gear. Finally, the transducers may be able to be removed from the head gear and then to be replaced in another location around the head gear. As a minimum, the user should be able to locate transducer at the front and the back of the head. By moving the transducers, the user may improve both perceived personal sound quality and personal comfort for wearing the

device.

## BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, aspects and advantages will be better understood from the following detailed description of a preferred embodiment of the invention with reference to the drawings, in which:

Figure 1 shows a user wearing the waterproof recreational audio device, system as a head band.

Figure 2 shows one or several transducers located within the headband.

Figures 3a shows the means of connecting and moving the transducers relative to the user and the head band by sliding the transducers along a guide on the head band.

Figure 3b show the means of connecting and moving the transducers relative to the user and the head band using hooks or snaps.

Figure 3c show the means of connecting and moving the transducers relative to the user and the head band using Velcro.

Figure 4 shows a simple block diagram for amplifier unit.

Figure 5a shows the components of the high frequency transducer.

Figure 5b shows one embodiment of waterproofing on a cross section of a transducer with the head band.

Figure 6a shows a wired connection to a sound source.

Figure 6b shows a wireless connection to a sound source.

Figure 7 shows a configuration of the device attached to a hat.

Figure 8 shows a configuration of the device attached to a helmet.

Figure 9 shows a configuration of the device attached to swim goggles.

Figure 10 shows another embodiment with a transducer located on the frontal region of the head and a stabilizing strap across the top of the

user's head.

## DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Referring now to the drawings, and more particularly to Figure 1, the preferred embodiment of the waterproof recreational audio device is as a comfortable, light weight head band 1 worn by a user. The head band 1 in Fig. 1 can be worn with eye wear such as swimming goggles. The transducer 2 is located on the inside of the head band 1 to allow contact with the head of the user as shown in Figure 2. Sealed, waterproof wiring (not shown) would be located inside the head band for connecting to a signal source.

One of the major advantages of the waterproof, recreational audio device is the tuning capability. The skull has many vibratory modes which are likely to be specific to an individual. The unique vibratory pattern of a head is a product of the skull and brain complex geometry, mass and other acoustic properties. The listener compensates for poorly propagating areas of the skull by moving the transducer 2 around the head until optimal sound quality is obtained. Placement at different locations (frontal, temporal parietal occipital etc.) may dramatically improve listening quality since the head is part of the propagating medium for bone conducted sound on the way to the inner ear.

A preferred configuration is to have two or more transducers 2 located at different positions around the head band 1 (e.g., 180° apart). The user could then tune the sound by rotating the head band 1 around the head. Another means for tuning the sound would be to locate the transducers 2 by sliding them around the head band 1on a slide positioning guide 3 shown in Figure 3a. Figure 3b shows the use of hooks/snap positioning means 4 connections that would be used to locate the

transducers 2 at several positions around the head band 1. Figure 3c shows hook and loop material (e.g., Velcro ®) inside the head band 1 as the means to allow the user to remove and replace the transducers 2 in preferred positions around the head band 1 for tuning.

In order to maximize the sound quality of the musical signal, the sound source is amplified and split into three frequency channels. The amplifier unit shown in Figure 4 is powered by a battery 17. A source signal 18 is received from the sound source and presented to the pre-amps 22 on the driver board 19. The signal source is split into the three frequency channels by the band pass filters 24.

Amplifiers 23 further enhance the low frequency channel, mid frequency channel, and high frequency channel signals. There are three attenuators 21, each controls the volume in each of the frequency channels. The listener increases the volume until comfortable in each channel. In this way compensation for the individual differences in sensitivity or preference is obtained. The mid frequency attenuator is preferably set with a maximum level of 90dBa for 8 hours to limit the volume of the mid range such that individuals near the listener should not be able to hear the sound.

The three channel signal drivers 20 couple the signal to the appropriate transducer 2. The low frequency transducer 2 can be an Audiological Engineering Inc. device or similar device. The mid frequency transducer 2 can be a Radioear Corporation device or similar device, and the high frequency transducer 2 can be a custom designed device from Blatek Inc. further described in Figure 5a, or a similar device. The high frequency sound signal 25, mid frequency sound signal 26 and low frequency sound signal 27 are heard by the user through contact with the transducers 2 to the head of the listener.

The high frequency transducer shown in Figure 5a may be constructed to include of a 1.215 inches dia. X .032 inches thick aluminum

disk 12. The aluminum disk 12 is located on top of the .05 inches dia. X .020 inches thick Lead Zirconate Titanate (PZT) disk 13. The PZT (ultrasonic) disk 13 sits within an Aluminum collar 14 that has an outer diameter of 1.25 inches with a wall thickness of .052 mm. The size of the components can vary, which will alter the vibratory response. This may be valuable in some applications. The aluminum collar 14 has a recess machined such that the aluminum disk 12 fits flush along the top of the aluminum collar 14, and the PZT disk 13 vibrates within the cavity created by the aluminum collar 14 and the aluminum disk 12. The signal source is received by the transducer via the wire connected to the insulated solder pin 15 and is grounded by the case ground solder pin 16. The insulation pin can be replaced on one side allowing the connector wire to cross the interior of the transducer.

The intended embodiment of the waterproof recreational audio device/system is to be able to operate in underwater and other high humidity environments. Examples of sub-aquatic, underwater environments include, but are not limited to, recreational and competitive swimming. However, it also includes, but is not limited to, scuba diving or other deeper water environments. Examples of above-water, high humidity environments include, but are not limited to, jogging, bicycling, hiking or other recreational activities that might expose the device and ear canal to excessive moisture, such as with rain, thereby interfering with normal air-conducted sound.

As such, in most applications of the invention, the transducers should be waterproof. Figure 5b shows a cross section of the transducer 2 connected to the head band 1. The transducer 2 preferably is waterproofed by rubberized or polymer coating 6. Water proofing is a accomplished by silicone sealing or silicone gaskets may also be used. The main function of the waterproofing is to protect the transducers from a water or humid environment (e.g., rain), while at the same time allowing the transducers to

transmit, via bone conduction, the musical signal to the wearer. As such, any waterproofing that accomplishes this objective might be used in the practice of this invention.

Another embodiment of waterproof recreational audio device is to include the sound source as part of the system. The sound source can be an MP3 player, CD player, or other portable musical device. The sound source 7 can be worn on the arm of the listener as shown in Figure 6a and 6b. The sound source is coupled to the head band 1 by a wired connection 8 shown in Figure 6a or by a wireless connection as shown in Figure 6b. The wireless connection would comprise a sound source wireless means 9a that would communicate with the head band wireless means 9b by transmitting and receiving the sound signals as radio, supersonic, or similar transmission means.

Although the preferred embodiment is a head band 1, the listener may want to use other types of head gear to position the transducers 2 in contact with the head. Figure 7 shows the transducers 2 are preferably located within a hat 28 that would be worn by the user. The transducers 2 are located inside the hat, next to the head of the listener. Other embodiments would be to locate the transducers 2 inside a helmet 29, such as a bike helmet 29 shown in Figure 8 or to locate the transducers 2 on the band of eye wear such as the goggles 30 shown in Figure 9.

Comfort of the user and tuning of the signal are major features for the waterproof recreational audio device. In the event a user wants to position at least one of the transducers 2 on the frontal region of the head, a stabilizing strap 11 is available to hold the head band 1 more securely when a transducer 2 is fixed to the frontal position as shown in Figure 10. The amplification at the three different frequency bands can be independently adjusted providing a personalized audio experience of high fidelity. Unlike air conduction, in which the pathway is the same for all frequencies, the skull unique geometry for each individual requires the

device to be tune for maximum satisfaction. Tuning the frequency bands is accomplished by manipulating three attenuators, each of which controls the volume in each of the frequency channels. The listener increases the volume until comfortable in each channel. When all are at a comfortable listening level the user can fine tune the response of all three channels in air and again underwater. In this way compensation for individual differences in sensitivity or preference is obtained. If the listeners wishes the audio image to appear in the center of the head, careful adjustment of the volume is necessary in all three channels

Tuning the volume of the three channels still may not result in the optimal high fidelity experience of sound in the head. Tuning the transducers to the head by positioning may be required. The skull has many vibratory modes which are likely to be specific to an individual. The unique vibratory pattern of a head is a product of the skull and brain complex geometry, mass and other acoustic properties. The listener compensates for poorly propagating areas of the skull by moving the tranducers around the head until optimal sound quality is obtained. Placement at different locations (frontal, temporal, parietal, occipital, etc.) will dramatically improve listening quality since the head is part of the propagating medium for bone conducted sound on the way to the inner ear. Transducer adjustment underwater may also be necessary given that medium's difference in acoustical properties from air.

The fidelity of the sound underwater with the device may be enhanced by ear plugging through a masking phenomenon that reduces sound interference of impeded air-conducted sound. This ear plugging can be accomplished with commercially available ear plugs (e.g., silicon); or, at a suitable water depth, there will be normal water loading of the external auditory canal. However, the latter method may not be reliable with recreational or competitive swimming, and ear plugging may be desired. The user may elect, however, not to use ear plugs, and a quality fidelity

sound will still be accomplished with the device. Placing plugs in the ear canal changes the quality of sound by bone conduction. This is termed the occlusion effect (Tonndorf, J. A new concept of bone conduction, *Arch Otol* 87, 49-54, 1968) and it enhances bone conduction listening by increasing the perception of lower frequency sound. The use of plugs or not is the listeners choice. Plugs will require intensity adjustment and possibly transducer placement on the head to create the optimal audio experience.

While the invention has been described in terms of a single preferred embodiment, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the appended claims.

## CLAIMS

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is as follows:

1. A waterproof recreational audio device for providing musical signals to a user, comprising:

at least one transducer, such that said transducer enables music to be heard by said user via transcutaneous bone conduction;

a means for said at least one transducer to be in vibratory contact with the head of said user; and

means for waterproofing said at least one transducer.

2. The waterproof recreational audio device according to claim 1, wherein said at least one transducer includes a plurality of transducers.

3. The waterproof recreational audio device according to claim 2, wherein said plurality of transducers is arranged in an array.

4. The waterproof recreational audio device according to claim 2, wherein the musical frequency range is split into three frequency channels.

5. The waterproof recreational audio device according to claim 4, wherein said three frequency channels consist of:

a low frequency range,

a mid frequency range, and

a high frequency range.

6. The waterproof recreational audio device according to claim 3, wherein at least one of said transducers in said array is an ultrasonic transducer.

7. The waterproof recreational audio device according to claim 3, wherein at least one of said transducers in said array is a vibrotactile transducer.

8. The waterproof recreational audio device of claim 1, wherein said audio device includes at least one amplifier.

9. The waterproof recreational audio device according to claim 1, wherein at least one of said transducers is positionable at the front of the head of said user.

10. The waterproof recreational audio device according to claim 1, wherein at least one of said transducers in said array is positionable at the back of the head of said user.

11. The waterproof recreational audio device according to claim 1, wherein said transducer is associated with a band that encircles the head of a user.

12. The waterproof recreational audio device according to claim 1, wherein said transducer is associated with a hat that is worn on the head of said user.

13. The waterproof recreational audio device according to claim 1, wherein said transducer is associated with a helmet that is worn on the head of said user.

14. The waterproof recreational audio device according to claim 1, wherein said transducer is associated with a band of recreational eye wear selected from the group consisting of swim goggles, ski goggles, snorkel mask, and sun glasses.

15. The waterproof recreational audio device according to claim 5, wherein said low frequency range volume is adjustable.

16. The waterproof recreational audio device according to claim 5, wherein said mid frequency range volume is adjustable.

17. The waterproof recreational audio device according to claim 5, wherein said high frequency range volume is adjustable

18. The waterproof recreational audio device according to claim 1, wherein said mid frequency range has a fixed maximum signal level of 90 dBa for 8 hours.

19. The waterproof recreational audio device of claim 1, wherein said waterproof recreational audio device transmits a musical signal of a high fidelity frequency response across a broad frequency range where there is:

a low frequency response is in the range of 40 - 1000 Hz

a mid frequency response is in the range of 250 - 6000 Hz, and

a high frequency response is in the range of 5000 - 20,000 Hz.

20. The waterproof recreational audio device of claim 19, wherein said at least one transducer includes an ultrasonic transducer.

21. The waterproof recreational audio device of claim 19, wherein said at least one transducer includes a vibrotactile transducer.

22. The waterproof recreational audio device of claim 19, wherein said waterproof recreational audio device includes an adjusting capability for the mid range frequency response, such that:

said mid frequency range volume can be adjusted to allow environmental noise to be heard by the user,

said mid frequency range has a fixed maximum level to minimize nuisance noise for individuals near said waterproof recreational audio device, and

said mid range has a fixed maximum level to restrict harmful dB noise levels for user.

23. The waterproof recreational audio device of claim 19, wherein a volume of said low frequency range is adjustable.

24. The waterproof recreational audio device of claim 19, wherein a volume of said mid frequency range is adjustable.

25. The waterproof recreational audio device of claim 19, wherein a volume of said high frequency range is adjustable.

26. The waterproof recreational audio device of claim 19, wherein said mid frequency range has a fixed maximum signal level of 90 dBa for 8 hours.

27. The waterproof recreational audio device of claim 1 further comprising a sound source in communication with said at least one

transducer, said sound source generating a music signal which is received by said at least one transducer.

28. The waterproof recreation audio device of claim 27 wherein said communication between said sound source and said at least one transducer is via a wired connection.

29. The waterproof recreation audio device of claim 27 wherein said communication between said sound source and said at least one transducer is via a wireless connection.

30. The waterproof recreation audio device of claim 27 wherein said sound source is affixed to said means for said at least one transducer to be in contact with the head of said user.

31. The waterproof recreation audio device of claim 27 wherein said sound source is selected from the group consisting of MP3 player, tape player, radio, audio transceiver, and disc player.

32. A recreational audio device, comprising:

at least one transducer which enables music to be heard by a user via transcutaneous bone conduction; and

a support which supports said at least one transducer in contact with a head of a user at a plurality of locations around the head of said user.

33. The recreational audio device according to claim 32 wherein said at least one transducer includes a plurality of transducers.

34. The recreational audio device according to claim 32 wherein said at least one transducer can be removed from said support and re-positioned at at least one different location on said support.

35. The recreational audio device according to claim 32 wherein said at least one transducer can slide to different locations on said support.

36. The recreational audio device according to claim 32 wherein said support can be oriented at multiple orientations relative to a head of a user.

37. The recreational audio device of claim 36 wherein said support is a head band.

38. The recreational audio device of claim 32 further comprising waterproofing for said at least one transducer.

39. The recreational audio device of claim 32 further comprising a sound source for conveying musical signals to said at least one transducer.

40. A method for a user to listen to music via transcutaneous bone conduction, comprising the steps of:

supplying musical signals from a source to at least one transducer capable of transcutaneous bone conduction;

contacting a user's head with said at least one transducer; and

transmitting by transcutaneous bone conduction said musical signal to the user.

41. The method recited in claim 40, further comprising a step of tuning musical sound heard by a user.

42. The method of claim 41 wherein said step of tuning comprises changing point of contact of at least one transducer on a user's head.

43. The method of claim 42 wherein changing is accomplished by repositioning a support which supports said at least one transducer on said user's head.

44. The method of claim 42 wherein changing is accomplished by repositioning said at least one transducer on a support which supports said at least one transducer.

45. The method of claim 42 wherein changing is accomplished by sliding said at least one transducer to a different location on a support which supports said at least one transducer.

46. The method of claim 40 comprising adjusting volume of at least one a high, mid, or low frequency transmitted via transcutaneous bone conduction via said at least one transducer.

47. The method of claim 40 further comprising limiting a mid frequency range has a fixed maximum signal level of 90 dBa for 8 hours.


Figure 1

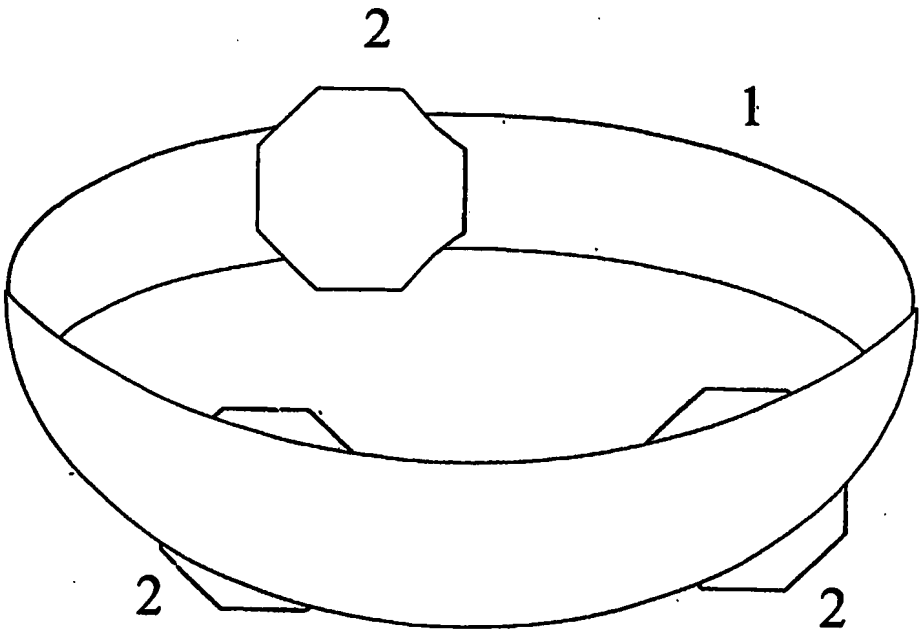


Figure 2

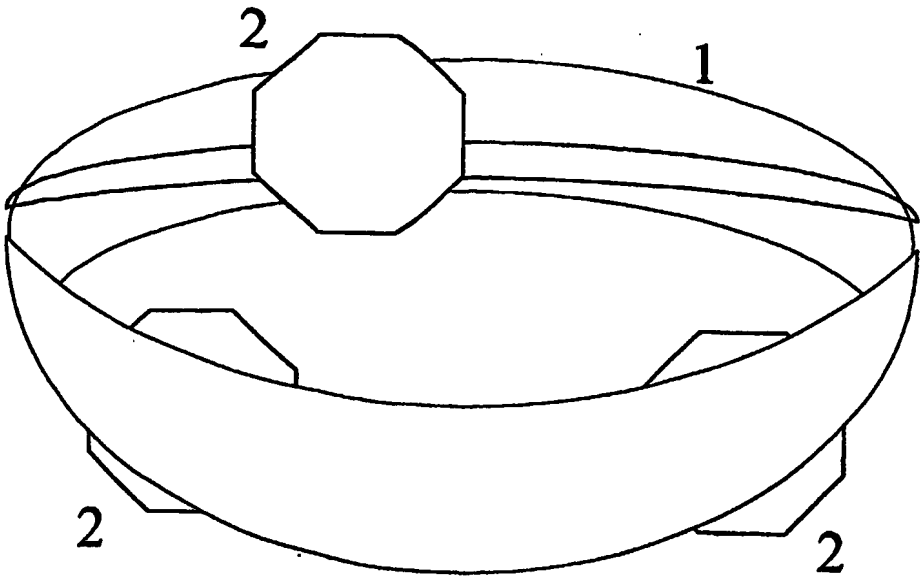


Figure 3a

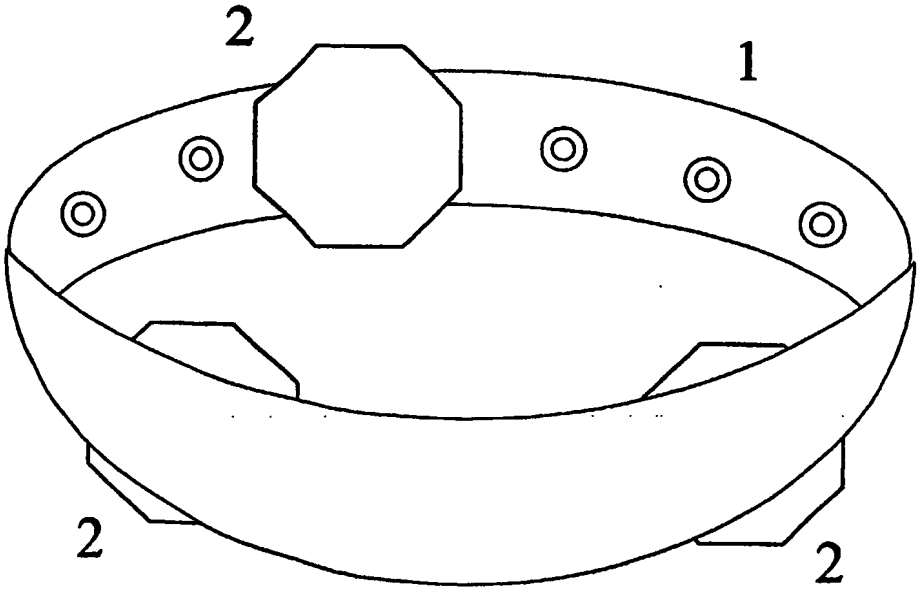


Figure 3b

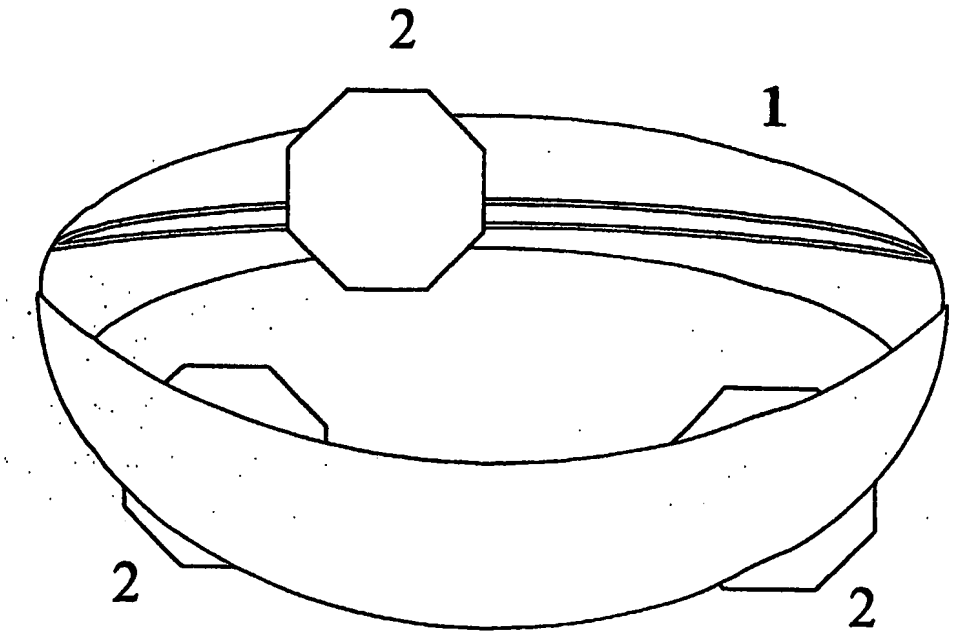


Figure 3c

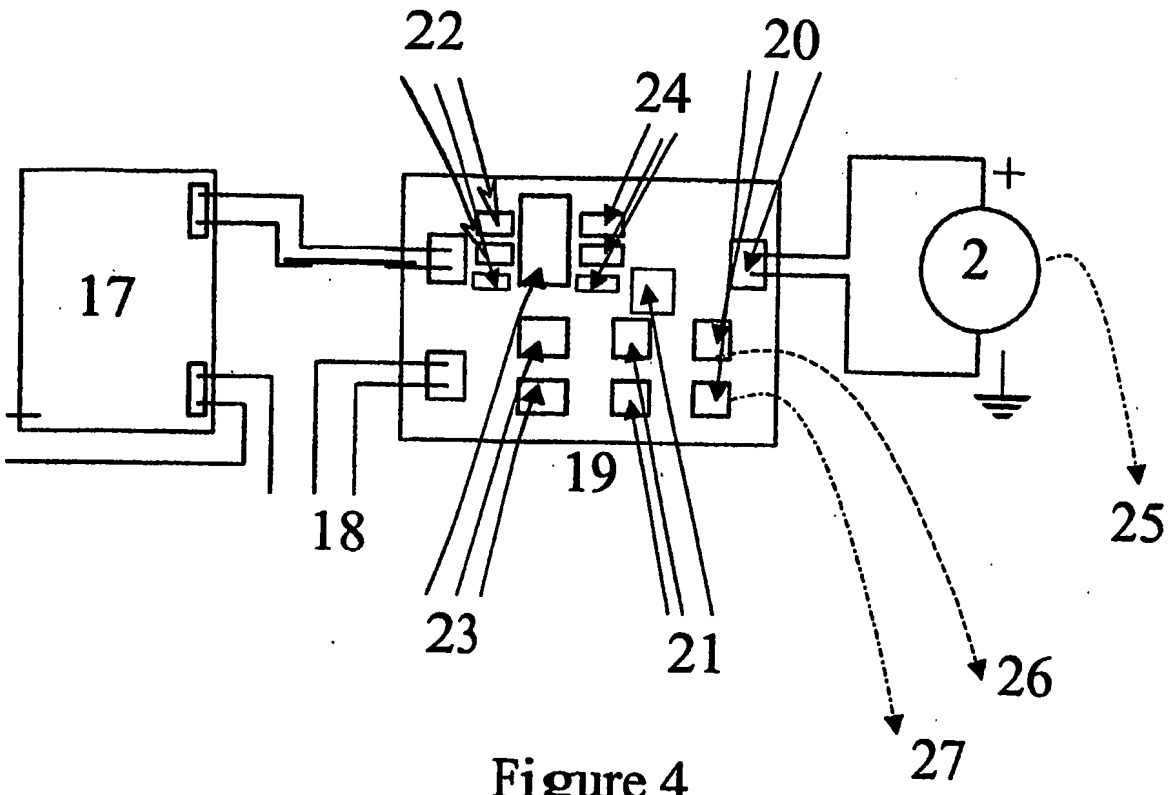


Figure 4

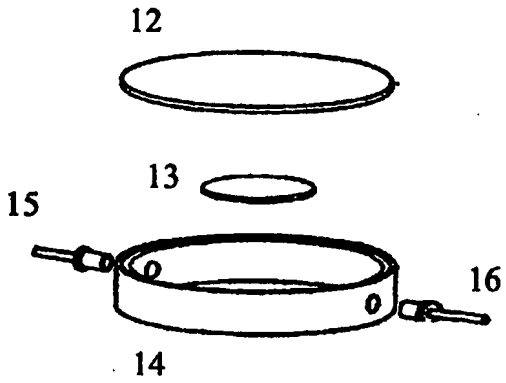


Figure 5a

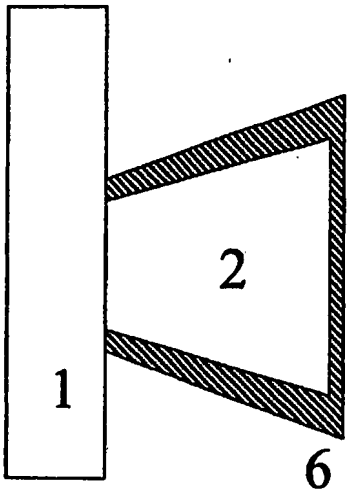


Figure 5b


Figure 6a


Figure 6b

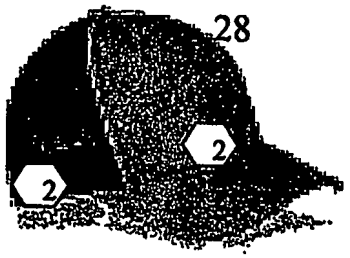


Figure 7


Figure 8

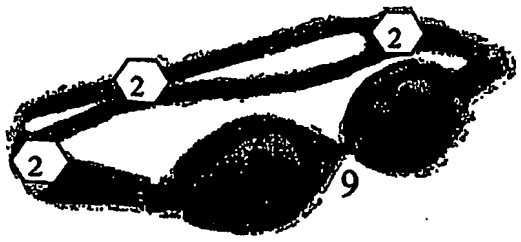


Figure 9

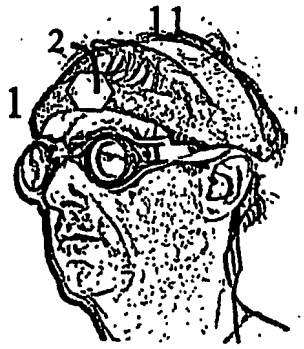


Figure 10